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High-gain, Nd-doped-glass preamplifier for the National Ignition Facility (NIF) laser system

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Abstract

We describe a high-gain, $G>10^{10}$, preamplifier prototype designed for the National Ignition Facility (NIF) laser system. The preamplifier contains a stable, diode-pumped regenerative amplifier, optical subsystems for spatial shaping and smoothing, and a large diameter, four-pass, rod amplifier.

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Summary

The large, glass laser system for the National Ignition Facility (NIF) is comprised of 192 separate beam lines that each produce about 20 kJ of 1.05 micron light. The architecture consists of a central, all-fiber master oscillator system, where the light is generated, shaped, modulated, and distributed to 192 beam lines. Next, 192 preamplifier modules amplify the tailored pulses from 1 nJ up to 10 J, whereupon they are transported to the large amplifier chains where the laser energy is increased to the 20 kJ level. The preamplifier modules contain a diode-pumped regenerative amplifier (regen), two optical subsystems for spatial beam shaping and smoothing by spectral dispersion (SSD), and a larger four-pass amplifier. All four of these optical subsystems will be housed in the preamplifier module (or PAM) along with the energizing, control, and diagnostic instrumentation. In this paper we describe the current design and performance of this high-gain preamplifier.

The regenerative amplifier is a folded-linear, TEM_{00} cavity that must be able to contain a 20 ns long, temporally-shaped pulse. At either end of the cavity are diode-pumped, 5X50 mm rod amplifiers that are end pumped by 48 bar, diode arrays. The diode light is focused with micro-lenses into a tapered lens duct that funnels light down into the end of the 5mm diameter laser rod.[1] Each rod stores about 300 mJ of energy in the upper laser state from 2 kW of optical pump power in a 350 μs pulse. The total available energy in the cavity eigenmode is about 60 mJ. The 1 nJ input pulse is amplified to 10 mJ in about 15 round trips in the regen, requiring a total gain of 10^7. To preserve the specific temporal shape of the input pulse, the regen is limited to a square-pulse-distortion of 1.2. To achieve an acceptable energy balance among the 192 arms of the laser, the regen must have a pulse-to-pulse stability < 3% rms.

The diffraction-limited Gaussian pulse emerging from the regen is formed into a square pulse that is spatially shaped in both transverse dimensions to compensate for the nonuniform spatial gain profile in the rod amplifier as well as the large aperture slab amplifiers. The square beam illuminates a serrated aperture that is relay-imaged through the rest of the laser system. A second optical system for smoothing by spectral dispersion (SSD) is included in the preamplifier module after the spatial beam shaping section. In our presentation we will discuss designs for both one and two dimensional smoothing.

The second laser system in the preamplifier contains a 45 mm diameter, flashlamp-pumped, rod amplifier in a four-pass optical configuration. The input leg contains a 45 mm Faraday rotator that provides isolation of the regen from backward traveling pulses from the large amplifiers. The rod amplifier, which was designed and built at LLNL for the Petawatt and NIF preamplifier, is a 12 lamp design and produces a single-pass gain of 12-14. The total gain of the four-pass amplifier is 10^4 and the square-pulse-distortion is less than 2. The square-shaped beam produced in the beam shaping section is relay-imaged through the four-pass system producing up to 12 J at the output of the preamplifier. In our presentation we will discuss the design and performance of the preamplifier and how it integrates with the rest of the NIF laser system.

1. R. Beach, P. Reichert, W. Benett, B. Freitas, S. Mitchell, S. Velsko, J. Davin, and R. Solarz, "Scalable diode-end-pumping technology applied to a 100 mJ, Q-switched Nd^{3+}:YLF laser oscillator", Opt. Lett. **18**, 1329 (1993).

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